MINIMUM SANITATION PROTOCOLS FOR OFFSHORE GERANIUM CUTTING PRODUCTION

The purpose of this document is to establish *minimum* sanitation protocols to prevent the introduction of *Ralstonia solanacearum* race 3 biovar 2 into production greenhouses at off-shore facilities that produce geraniums intended for import into the United States.

The management pertains to geraniums propagated in "Increase", and "Production Block" greenhouse facilities where the plant material originates from an "Elite Nucleus Block" (tissue culture). In order to prevent cross contamination of the "Increase" and "Production Block" facilities:

- There is to be a complete physical separation of Increase and Production Blocks which involves the use of dedicated structures.
- Personnel are not to enter the Increase Block if they have entered the Production Block on the same day.
- Equipment and protective clothing is dedicated for sole-use in Production and Increase Blocks when crop is present.

Minimum Standards for Greenhouse Structure and Material Requirements:

Facility Infrastructure: All geranium plant material grown for the purpose of production of geranium cuttings destined for the US must be propagated and maintained in greenhouses. Greenhouses are covered (glass, polycarbonate, or polyethylene) to prevent splashing due to rain. Sides of greenhouse facilities are enclosed with screen. The outer perimeter of the greenhouse is to be surrounded by a buffer that may be composed of gravel or crushed rock, grass free of dicotyledonous plants/weeds, concrete or similar hard surfaces or weed-cloth and should be a minimum of 1m in width. The buffer should be sloped such that water drains away from the greenhouse and greenhouses are designed so that seasonal rain or flood waters do not enter greenhouses.

Greenhouse flooring varies among facilities. Hard surface floors such as concrete or crushed rock with overlay of weed-block are essential. Regardless of flooring type, direct contact of production stock plants with the floor is prohibited. Equipment surfaces in contact with stock production plants may not come in contact with the floor unless they have been surface disinfested prior to use. This includes the ends of hoses or watering wands which may be used to water production stock plants. Additional conditions pertaining to flooring are identified below.

Entry to facilities must be through a door providing direct access to an area within each greenhouse that is equipped with wash station(s), foot bath(s), and protective clothing (aprons, lab coats, etc) to be used by all entrants of the facility prior to entering plant production areas. Facility design and the practices of hand and foot/shoe disinfestations and the covering of clothing worn outside the greenhouse production area are implemented to

significantly reduce the likelihood of introducing *R. solanacearum* into geranium facilities. Sanitation practices are to be strictly enforced.

Wash stations: All exposed body parts (hands, arms, legs, etc) that may come in contact with plant material are to be washed with or dipped into disinfectant prior to entering the production area of the greenhouse as described in Table 1.

Foot baths: The foot wear of all persons entering the greenhouse are to be brushed or rinsed free of soil and debris prior to entry of the facility; this will improve treatment efficacy and prolong the activity of the surface disinfectant. Each person entering the greenhouse facility is subsequently required to rinse shoes, boots or other foot wear in a reservoir of surface disinfectant (Table 1). The volume of disinfectant used in footbaths is to be adequate to ensure that soles and lower portions of footwear that may have come in contact with *R. solanacearum* race 3 biovar 2 are moistened with disinfectant and remain wet for the minimum amount of time required for the particular disinfectant to be effective. The disinfectant in these reservoirs is to be changed a minimum of twice daily, with debris in reservoirs being removed prior to replacement of the disinfectant into the footbath. The bottom surface of the reservoir shall be rough in texture so as to facilitate dislodging of any debris on the bottom of shoes/boots (this may be accomplished by placement of a mat inside the reservoir). Daily records are initialed by responsible personnel to demonstrate that foot baths etc. were properly maintained.

Protective clothing: Protective clothing (clean lab coats or aprons) is to be worn by all personnel upon entry of the greenhouse production area. The purpose of the protective clothing is to prevent contact of geraniums with employee clothing worn outside the increase and production areas. Protective clothing designated to come into contact with the geranium crop (washable or disposable aprons worn over lab coats or lab coats) is to be dedicated to each greenhouse facility and is to be put on after leaving the hand wash and foot bath station but prior to entering the plant production area. Protective clothing is to be removed prior to leaving each greenhouse facility but prior to entry into the hand wash/footbath area. Protective clothing is to be stored such that there is no contact with the floor. Clothing is to be maintained free of debris, potting media, soil, or plant material. Protective clothing should be washed in detergent weekly or replaced in the case of disposable aprons.

Personal Hygiene: Sanitation of hands or forearms that come in contact with geraniums must be maintained throughout the period when workers are in the greenhouse facility during production. This may be accomplished by either dipping hands or forearms in disinfectant or by spraying hands and forearms with disinfectant. Workers may select to wear latex or equivalent gloves and these are also to be sprayed or dipped in surface disinfectant as described for hands and forearms. Workers must regularly surface disinfest their hands and forearms by dipping or spraying with disinfectant between groups of 10 plants or between definable production units of geraniums that are delimited by production practices (Table 1).

Tools: Greenhouse equipment used to harvest cuttings or for other functions involving contact with geraniums is to be surface disinfested prior to and between use on each stock production plant or stock production container. Carts and collection baskets are to be sprayed with a surface disinfectant on all surfaces that are likely to come into contact with geranium cuttings or equipment used in processing geranium cuttings. Equipment (knives, etc) used to harvest cuttings is to be soaked in surface disinfectant when not in use and is to be rotated between each stock plant or stock plant container. The volume of disinfectant used to surface disinfest tools should be adequate to submerge entire blade or portions of tools that make contact with geranium plants. (Table 1).

Handling of cuttings: Upon harvest, cuttings are placed directly into new plastic bags or into plastic containers that can be surface disinfested before they are used again. Labels will accompany each bag of cuttings. The label system will be such that it allows cuttings to be traced forward thorough the rooting stations (if cutting is sold as rooted cutting), or directly from the farm (if cutting is sold as un-rooted or callused) to the first wholesale grower customer.

Transfer of cuttings to grading facilities shall be done in a manner so as to ensure that bags of cuttings do not come in contact with soil, plant, or other material that may harbor *R. solanacearum* race 3 biovar 2.

Greenhouse floors: Greenhouse floors should be maintained free of debris and weeds. Floors must drain so as to prevent puddling. Water in contact with flooring is never in contact with surfaces upon which plants are grown (splashing, watering, etc). Plant material (cuttings, trimmings, etc) that falls to the floor should not be retrieved by greenhouse workers who are in the process of handling production stock plants; it should be removed on a periodic basis (minimum weekly) and disposed of by other workers or by same workers after harvesting of cuttings is completed. Floors are to be sanitized twice annually; when greenhouses are cleared of stock production plants and when they are set up for the next growing season (Table 1).

Flooring throughout all greenhouses must be composed of concrete (or similar material) or crushed rock/gravel covered with weed-block. Floors in greenhouses are not permitted to be comprised of exposed soil/dirt; no exposed soil/dirt is allowed in greenhouses.

Production surfaces: The distance between the surface upon which the stock production plants are placed to the greenhouse floor and the types of surfaces upon which stock production plants are grown varies among greenhouse facilities. Stock production plants are to be elevated above the greenhouse floor so as to prevent contamination from splashing water and to ensure that there is no continuum between plant material and water, debris, or potting media on the floor. Surfaces upon which plants are grown should be disinfested (Table 1) prior to use and constructed such that water draining from pots does not make contact with other pots.

Potting Media: Geranium stock plants are to be grown in media that has been treated to prevent the presence of Ralstonia. New plastic bags or pots or recycled plastic pots that have been surface disinfested may be used as stock plant containers. Potting media and pots intended for use in the greenhouse shall not be stored on soil/dirt or turf surfaces.

Irrigation: The requirement for treatment of irrigation water is dependent upon its source and the water storage and delivery system in use. Water treatment is not required for irrigation water collected from deep thermal wells which are properly sealed and where water is used directly or when stored in tanks such that there is no opportunity for contamination of the water supply by native soil or plant material/debris. If water sources are derived from un-sealed wells, rain-water collection systems, ponds, lakes, streams or any other type of open body of water or if water is recycled or recirculated, then treatment of water is required.

Two independent water purification systems are to be available in each geranium production facility to safeguard the crop from infection by Ralstonia. A back up system is required to ensure that the crop does not become infested with Ralstonia due to failure of the water purification system. Water treatment systems effective against *Ralstonia solanacearum* race 3 biovar 2 are listed in Table 1.

Plants may not be irrigated using ebb and flow or flood irrigation systems as these methods foster spread of *R. solanacearum*. Irrigation systems should be constructed such that emitters are not in contact with potting media and/or are equipped with backflow devices so as to prevent contamination of the watering system. The last 4' of hose closest to the bench and hose-end implements used for hand watering geraniums should never come in contact with the floor of geranium production facilities or with plant material or potting media l. When such contact is made, the hose and watering implement must be treated with a surface disinfectant (Table 1). Hose ends used for watering shall be hung on a hook so as to prevent contact with the floor and with plant material on greenhouse benches. Never lay the hose ends on the floor or on greenhouse benches.

Survey and Detection of *Ralstonia* in Greenhouse Facilities: All plant material used to propagate stock production geranium plants and the subsequent stock plants themselves must be free of *Ralstonia solanacearum* prior to introduction into the production stock greenhouse. Diagnostics and sampling protocols identified in the prior section of this document are to be used for this disease indexing process. Records of disease testing are to be maintained and made available to APHIS upon request. In addition, plants are scouted regularly for signs of wilt, and tested for *R. solanacearum* as necessary. Where positive results are attained, all plants in the greenhouse are to be destroyed, and the greenhouse decontaminated. The infested facility is to be quarantined, until such time that APHIS exporting authorities (NPPO) are satisfied that the infestation has been eliminated. (Table 1).

Training of Personnel: Personnel instruction is an important component of good management practices. Training shall be provided to cover all production practices required to prevent *R. solanacearum* from entering and becoming established. Training shall include not only practices performed in the greenhouse, but should provide a fundamental understanding of how *R. solanacearum* can spread from plants commonly encountered in workers yards and environs and required sanitary practice to prevent infection Management must ensure that staff members understand and follow the practices identified herein before entering the greenhouse. Access to geranium stock

production facilities is limited to individuals certified to work in facilities, and a list of these personnel should be maintained. Personnel will be provided training annually or more frequently as required. Facilities should maintain records of training and certifications. Food is not to be allowed in or near the greenhouses.

Grading facilities: Counters in grading facilities are disinfected prior to placement of cuttings on work surfaces.

APHIS will amend these management practices as new knowledge and methods are developed/validated to detect and mitigate *Ralstonia solanacearum*.

Table 1: Treatments and Procedures

Wash stations:

Purpose: To prevent Ralstonia solanacearum from being introduced into greenhouses via contaminated skin (hands/forearms).

Composition: The wash station shall be located just inside the entry area of each greenhouse. It shall consist of a sink area that is supplied from a water supply that is from either a sealed well system or that has been treated for the purpose of Ralstonia solanacearum disinfestation. The water draining from the sink must not collect in the greenhouse; it is to drain immediately from the greenhouse facility.

Process: All exposed body parts (hands, arms, legs, etc) that come in contact with plant material are to be washed with antibacterial soap prior to each entry into the production area of the greenhouse. Proper handwashing protocols are as follows:

1. Wet: Wet hands first.
2. Soap: Apply antibacterial soap to palms.
3. Soap/Lather: Lather soap on hands, wrists and forearms
4. Wash: Work all surfaces thoroughly including wrists, forearms, palms, back of hands, fingers, and under fingernails – Rub hands together for a least 30 seconds.
5. Rinse: Thoroughly rinse with clean water. Be sure not to touch sides of sink.
6. Dry: Dry hands completely and use towel to turn off water (if foot pedal faucet is not available) to prevent hands from becoming reinfested.

Treatments: Antimicrobial soap.

Foot baths:

Purpose: To prevent Ralstonia solanacearum from being introduced into greenhouses via contaminated foot coverings.

Composition: A reservoir containing surface disinfectant effective against Ralstonia solanacearum is located between the entry of each greenhouse and the production area of each greenhouse. The bottom surface of the reservoir shall be rough in texture so as to facilitate dislodging of any debris on the bottom of shoes/boots (this may be accomplished by placement of a mat inside the reservoir). The depth of the footbaths is to be adequate to ensure that soles and lower portions of footwear that may have come in contact with *R. solanacearum* race 3 biovar 2 are wetted with disinfectant.

Process: The foot wear of all persons entering the greenhouse are to be brushed or rinsed free of soil and debris prior to entry of the facility; this will improve treatment efficacy and prolong the activity of the surface disinfectant. Each person entering the greenhouse facility is subsequently required to rinse shoes, boots or other foot wear in a reservoir of surface disinfectant. Foot coverings are to remain wet for a period adequate to allow for disinfectant to disinfest all contaminated footwear surfaces.

The disinfectant in these reservoirs is to be changed a minimum of twice daily, with debris in reservoirs being removed prior to replacement of the disinfectant into the footbath.

Personnel responsible for footbath maintenance shall read, understand, and execute formulation of footbath disinfectants; their accuracy should be verified by management. Daily records are initialed by responsible personnel to demonstrate that foot baths etc. were properly maintained.

Treatments: Surface disinfectants labeled for Ralstonia spp or Pseudomonas spp. may be used in the footbath reservoirs. Quaternary ammonium-based products are recognized as being effective and should be used in strict accordance with the label.

Protective Clothing:

Purpose: Protective clothing is used to prevent contact of geraniums with employee clothing worn outside the increase and production areas.

Composition: Protective clothing designated to come into contact with the geranium crop consists of washable or disposable aprons and/or washable lab coats. Protective clothing is to be dedicated to each greenhouse facility.

Process: Protective clothing (lab coats or aprons) is to be worn by all personnel upon entry of the greenhouse production area. Aprons or lab coats are to be put on after leaving the hand wash and foot bath station but prior to entering the plant production area. Protective clothing is to be removed prior to leaving each greenhouse facility but prior to entry into the hand wash/footbath area. Protective clothing is to be stored such that there is no contact with the floor. Clothing is to be maintained free of debris, potting media, soil, or plant material. If lab coats are worn between greenhouses within a production area, then they should be covered with or exchanged for an apron when workers enter the production areas of each greenhouse.

Treatments: Protective clothing should be washed in detergent weekly or replaced in the case of disposable aprons.

Personal Hygiene:

Purpose: To prevent infection of geraniums by Ralstonia solanacearum and when introduced to limit spread in production greenhouses if introduced.

Composition: Plastic spray bottles or containers filled with adequate amount of surface disinfectants are to be used by each worker in the greenhouse.

Process: Sanitation of hands or forearms that come in contact with geraniums must be maintained throughout the period when workers are in the greenhouse facility during production. This may be accomplished by either dipping hands or forearms in disinfectant or by spraying hands and forearms with disinfectant. Surfaces are to remain wet for time required for disinfectant to kill Ralstonia solanacearum as defined by product label.

Workers may select to wear latex or equivalent gloves and these are also to be sprayed or dipped in surface disinfectant as described for hands and forearms. Workers are to dip or spray hands with disinfectant between groups of 10 plants or between definable production units of geraniums that are delimited by production practices.

There is to be no eating in the greenhouses or greenhouse production areas.

Treatments: Surface disinfectants labeled for Ralstonia spp or Pseudomonas spp. may be used in spray bottles or in plastic containers used to dip hands. Quaternary ammonium-based products are recognized as being effective and should be used in strict accordance with the label.

Tools Used to Propagate and Harvest:

Purpose: To prevent the infection/spread of Ralstonia solanacearum through production/harvesting of geraniums.

Composition: Tools include any piece of equipment used in the process of production and harvest of geraniums and their cuttings which may come in contact with geraniums or their cuttings.

Process: Greenhouse equipment used to harvest cuttings or for other functions involving contact with geraniums is to be surface disinfested prior to and between use on each stock production plant or stock production container. Carts and collection baskets are to be sprayed with a surface disinfectant on all surfaces that are likely to come into contact with geranium cuttings or equipment used in processing geranium cuttings. Equipment (knives, etc) used to harvest cuttings is to be soaked in surface disinfectant when not in use and are is to be rotated between each stock plant or stock plant container. The volume of disinfectant used to surface disinfest tools should be adequate to submerge entire blade or portions of tools that make contact with geranium plants.

Treatments: Quaternary ammonium-based products are recognized as being effective against Ralstonia solanacearum and should be used in strict accordance with the product label.

Handling of cuttings:

Purpose: To prevent cuttings and crop from becoming infested with Ralstonia solanacearum and to identify the source production greenhouse for geranium cuttings.

Composition: Cuttings are sections of geranium stems harvested for the purpose of export to the United States for future propagation. Plastic bags may not be recycled and must be stored so as not to come in contact with the floor or native soil. Surface disinfested plastic containers may be used for collection of harvested cutting prior to the transfer of cuttings to plastic bags. Labels are plastic and information is marked in non-water soluble ink.

Process: Upon harvest, cuttings are placed directly into new plastic bags or into plastic containers that can be surface disinfested before they are used again. Labels will accompany each bag of cuttings. The label system will be such that it allows cuttings to be traced forward thorough the

rooting stations (if cutting is sold as rooted cutting), or directly from the farm (if cutting is sold as un-rooted or callused) to the first wholesale grower customer.

Transfer of cuttings to grading facilities shall be done in a manner so as to ensure that bags of cuttings or cuttings in plastic containers do not come in contact with soil, plant, or other material that may harbor *Ralstonia solanacearum*.

Treatments: Quaternary ammonium-based products are recognized as being effective against Ralstonia solanacearum. Surface disinfectants should be used in strict accordance with the product label for cleaning plastic baskets used to collect cuttings.

Greenhouse Floors:

Purpose: Greenhouse floors must be constructed and maintained in condition such that they safeguard greenhouse-grown geraniums from infection by Ralstonia solanacearum.

Composition: Flooring throughout all greenhouses must be composed of concrete (or similar material) or crushed rock/gravel covered with weed-block. Floors in greenhouses are not permitted to be comprised of exposed soil/dirt; no exposed soil/dirt is allowed in greenhouses.

Process: Greenhouse floors should be maintained free of debris and weeds. Floors must drain so as to prevent puddling. Water in contact with flooring is never in contact with surfaces upon which plants are grown (splashing, watering, etc). Plant material (cuttings, trimmings, etc) that falls to the floor should not be retrieved by greenhouse workers who are in the process of handling production stock plants; it should be removed on a periodic basis (minimum weekly) and disposed of by other workers or by same workers after harvesting of cuttings is completed. Floors are to be sanitized twice annually when greenhouses are cleared of stock production plants and when they are set up for the next growing season.

Treatment: Quaternary ammonium-based products are recognized as being effective against Ralstonia solanacearum. Surface disinfectants should be used in strict accordance with the product label for cleaning plastic baskets used to collect cuttings.

Production Surfaces:

Purpose: To safeguard the geranium crop from infection by Ralstonia solanacearum via plant-to-plant spread or via the greenhouse floor.

Composition: Production surfaces may be comprised of a variety of materials and designs but must ensure that they do not facilitate pot-to-pot spread and are of adequate distance from the floor to prevent infestation of geraniums.

Procedure: Stock production plants are to be elevated above the greenhouse floor so as to prevent contamination from splashing water and to ensure that there is no continuum between plant material and water, debris, or potting media on the floor. Surfaces upon which plants are grown should be disinfested prior to use and constructed such that water draining from pots does not make contact with other pots.

Treatment: Quaternary ammonium-based products are recognized as being effective against Ralstonia solanacearum. Surface disinfectants should be used in strict accordance with the product label for sanitizing greenhouse floors.

Potting Media:

Purpose: To safeguard geraniums from infection by Ralstonia solanacearum through the use of contaminated potting media.

Composition: Potting media does not contain native soil. All potting media must be steam pasteurized and may not be recycled. Plants are potted in new plastic bags or surface disinfected pots. Plastic bags are not recycled.

Procedure: Geranium stock plants are to be grown in new media containing no native soil. Media must be treated to render it free of Ralstonia before planting. New plastic bags or pots or recycled plastic pots that have been surface disinfested may be used as stock plant containers. Potting media and pots intended for use in the greenhouse shall not be stored on soil/dirt or turf surfaces.

Treatment: Potting media must be treated with steam for 1 hour at 80C. Fumigation of recycled potting media or containers is not acceptable as fumigants have not been demonstrated to be 100% effective on R. solanacearum. Pots to be recycled may be treated with surface disinfectants labeled for Ralstonia. Treatment must be in strict accordance with label.

Irrigation:

Purpose: Irrigation water is treated or source is protected from contamination by *Ralstonia solanacearum* which may infect geraniums in production greenhouses.

Composition: The requirement for treatment of irrigation water is dependent upon its source and the water storage and delivery system in use.

Procedure: Plants may not be irrigated using ebb and flow or flood irrigation systems as these methods foster spread of *R. solanacearum*. Irrigation systems should be constructed such that emitters are not in contact with potting media and/or are equipped with backflow devices so as to prevent contamination of the watering system. The last 4' of hose closest to the bench and hose-end implements used for hand watering geraniums should never come in contact with the floor of geranium production facilities or with plant material or potting media l. When such contact is made, the hose and watering implement must be treated with a surface disinfectant. Hose ends used for watering shall be hung on a hook so as to prevent contact with the floor and with plant ma terial on greenhouse benches. Never lay the hose ends on the floor or on greenhouse benches.

Treatment: The requirement for treatment of irrigation water is dependent upon its source and the water storage and delivery system in use. Water treatment is not required for irrigation water collected from deep wells which are properly sealed and where water is used directly or stored in tanks such that there is no opportunity for contamination of the water supply by native soil or plant material/debris.

Water sources derived from un-sealed wells, rain-water collection systems, ponds, lakes, streams or any other type of open body of water or if water is recycled or re-circulated, then treatment of water is required.

A minimum of two types of water purification systems are to be instituted for each geranium production facility to safeguard the crop from infection by Ralstonia. A back up system is required to ensure that the crop does not become infested with Ralstonia due to failure of the water purificatio n system.

Water treatment systems effective against *Ralstonia solanacearum* are:

Filtration of water through reed-bed systems and slow sand filters in combination with ozonation (0.4 ppm residual ozone for a minimum of 4 minutes).

Ultra violet irradiation: $300 J/m^2$ of UV light at 254 nm with at least 50% light transmission.

Peroxygen products: a minimum residual level of 4mg per liter of peracetic acid for 2 minutes. This may be achieved by injection of irrigation water during pumping at 15-$35 m^3$

per hour) with a commercial formulation of 50-100ml/m^3 of peracetic acid.

Chlorine dioxide: Dosage of 0.1mg per liter of residual dhlorine dioxide sustained for a two minue minimum reaction time will effectively kill Ralstonia solanacearum. This may be achieved by injecting irrigation water with 5mg per liter using a chlorine dioxide generator.

Disinfesting hose ends that have been in contact with greenhouse floors or other potentially hazardous surfaces may be treated with quaternary ammonium-based products which are recognized as being effective against *Ralstonia solanacearum*. Surface disinfectants should be used in strict accordance with the product label for sanitizing surfaces: in this case the watering hose.

Survey and Detection of *Ralstonia* in Greenhouse Facilities:

All plant material used to propagate stock production geranium plants and the subsequent stock plants themselves must be free of *Ralstonia solanacearum* prior to introduction into the production stock greenhouse. Diagnostics and sampling protocols identified in the previous documents sent are to be used for this disease indexing process. Records of disease testing are to be maintained and made available to APHIS upon request. In addition, plants are scouted regularly for signs of wilt, and tested for *R. solanacearum* as necessary. Where positive results are attained, all plants in the greenhouse are to be destroyed, and the greenhouse decontaminated. The infested facility is to be quarantined, until such time that APHIS exporting authorities (NPPO) are satisfied that the infestation has been eliminated.

Training of Personnel: Instruction of personnel is an important component of good management practices. Training shall be provided to cover all production practices required to prevent *R. solanacearum* from entering and becoming established. Training shall include not only practices performed in the greenhouse, but should provide a fundamental understanding of how *R. solanacearum* can spread from plants commonly encountered in workers yards and environs and required sanitary practice to prevent infection Management must ensure that staff members understand and follow the practices identified herein before entering the greenhouse. Access to geranium stock production facilities is limited to individuals certified to work in facilities. A list of these personnel should be maintained. Personnel will be provided training annually; or more frequently as required. Facilities should maintain records of training and certifications.

Grading facilities:

Grading Facilities are subject to the same conditions as greenhouse with respect to the following elements of this plan as described above:

Wash Stations

Hand Washing

Footbaths

Protective Clothing

Personal Hygiene

Tools

Handling of Cuttings

Greenhouse Floors

Production Surfaces

Treatment of Water

Training of Personnel

Table or counter surfaces upon which cuttings are handled must be periodically surface disinfested. Treatment of surfaces should be completed between bags or baskets of cuttings processed.

APHIS will amend these management practices as new knowledge and methods are developed/validated to detect and mitigate *Ralstonia solanacearum.*